Deepwater Project
Bofors Defence 57-mm L/70 Mk 3 Gun System
System Engineering

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Deepwater Presentation

- Introduction of System Engineering Project for the USCG
  - Requirements, Missions and the Deepwater IPT
  - National Security Cutter
  - 57mm L/70 Mk 3 Gun Introduction
- Logistics Demonstration
- Engineering Analysis
- Gun Certification
- System Engineering

System Engineering

- The transformation of missions and operational needs and requirements into an integrated system solution with concurrent understanding of the entire life-cycle needs and processes (i.e. to demonstrate, integrate, verify and test, produce and field a [weapon] system for the Government in our case, the USCG and USN).
- Ensure the compatibility, interoperability and integration of all functional and physical interfaces and ensure system definition and design reflect the requirements of all system elements.
- This presentation will review the system engineering elements of the Deepwater Gun Weapon System for the U. S. Coast Guard.

Deepwater IPT

- NSWC PHD/L asked to do Mission Analysis and an Analysis of Alternatives with UDLP
  - 5-inch, 76mm, 57mm, 40mm guns considered along with MK 160 GCS and MK 46 MOD 1 EOSS
- NSWC PHD/L participated in Deepwater IPT and AoA with USCG, NSWC/DD and OPNAV
  - Mission Area and Threat Analysis
  - Requirements
  - TOC Analysis

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Deepwater Objectives

Block Obsolescence

12

Increasing Logistics Demands

29

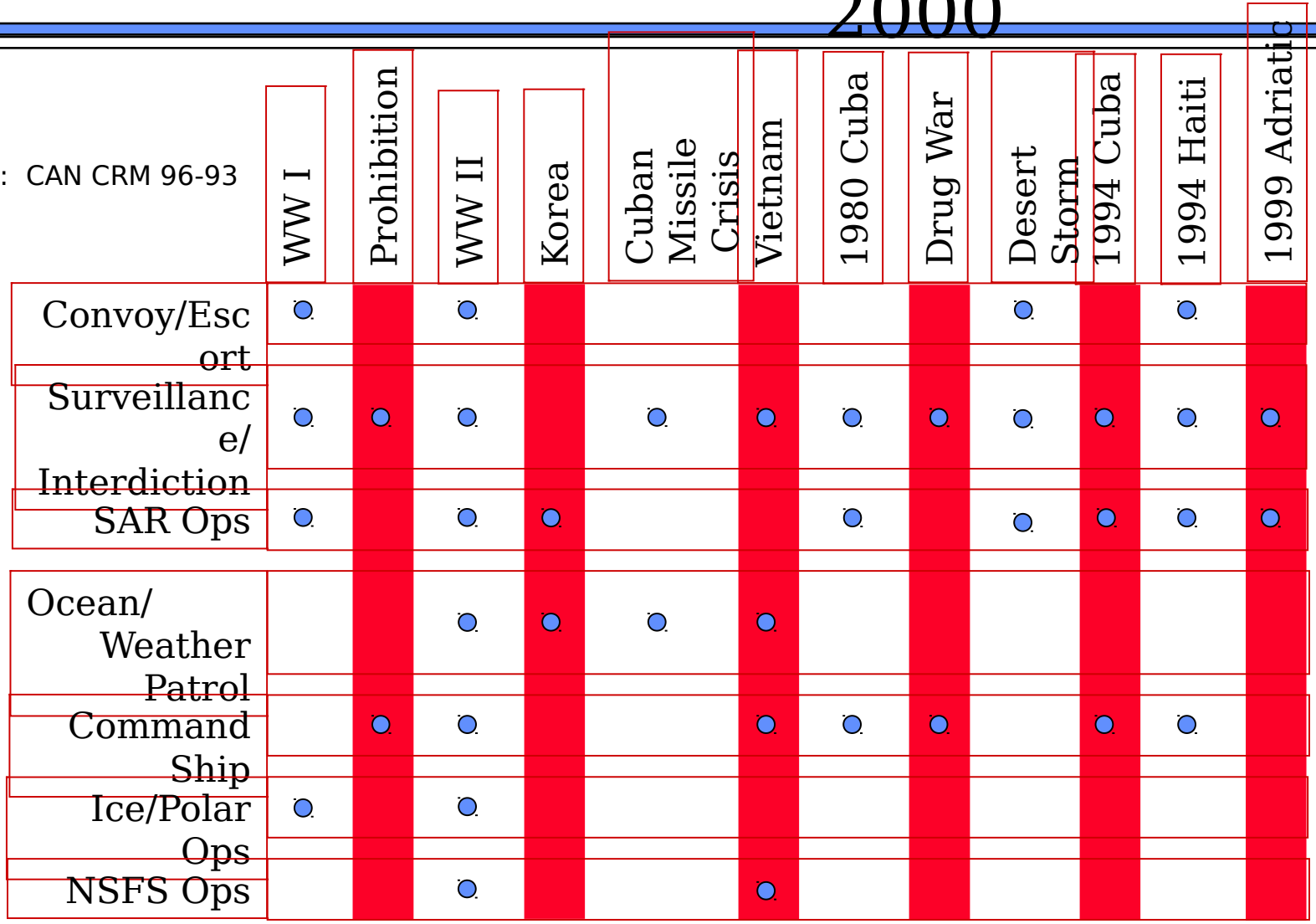
Capability Gap

49

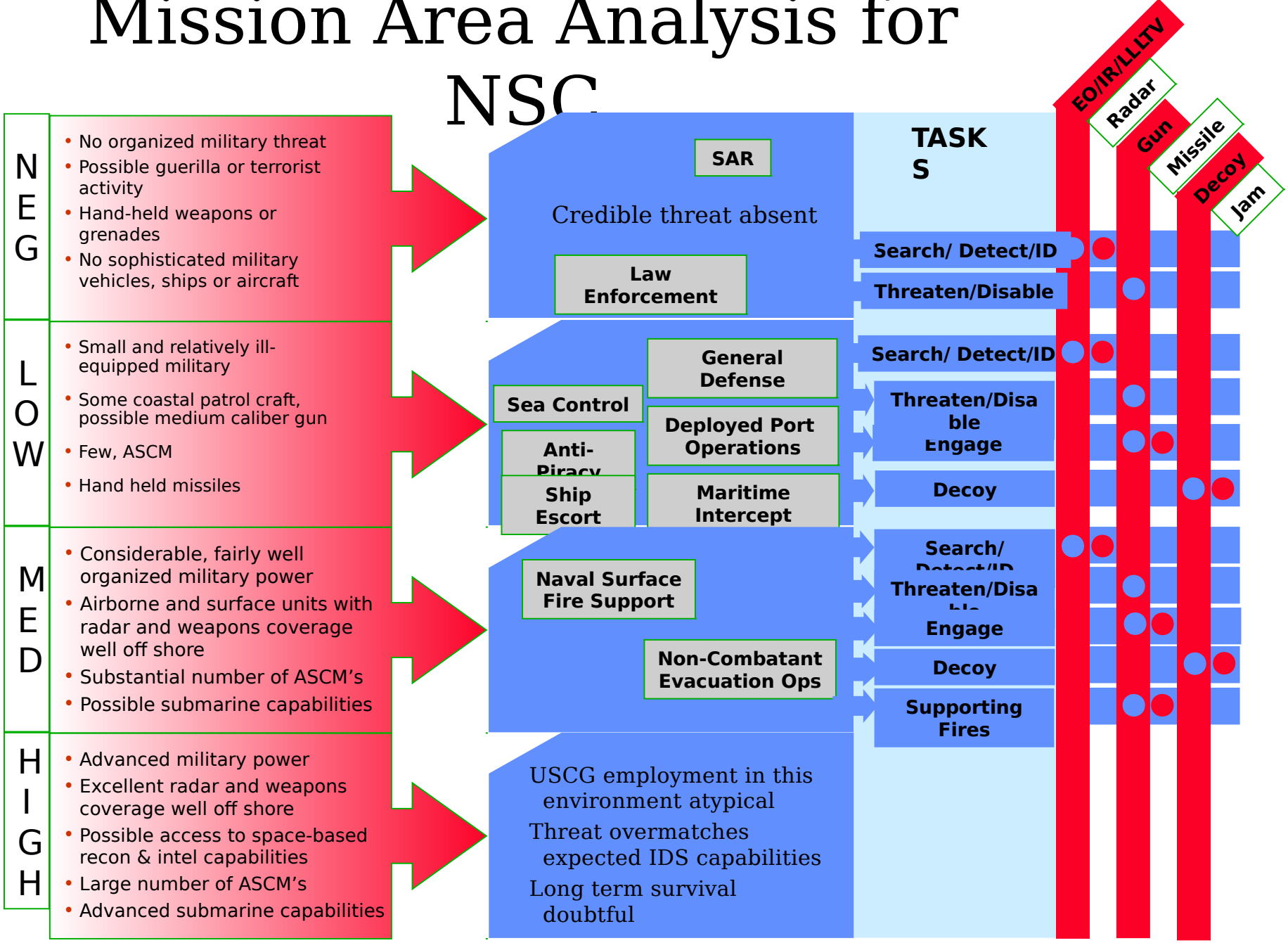
Notional Ships

USCG Wartime & Contingency Ops: 1917-2000

Source: CAN CRM 96-93



Mission Area Analysis for NSC

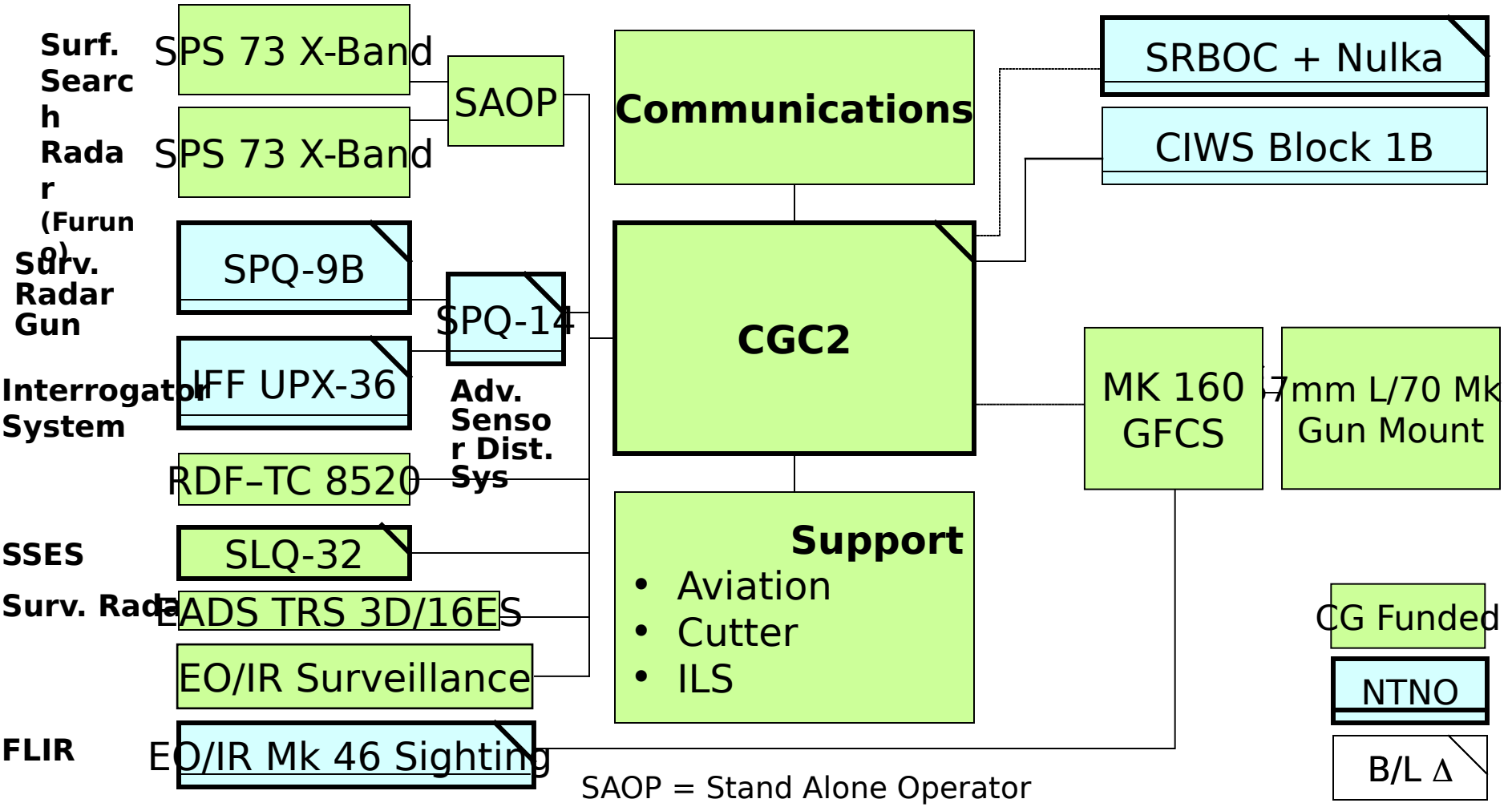


Low Threat Environment Weapons

	Trawler	Fast Attack Craft	Cigarette Boat (Type 4, Ashoora)	Boston Whaler	Boghammar
Size (length)	59 m	26 m	8 m	6.7 m	13 m
Speed (knots)	15	35 - 40	40+	40+	46
Manning	38	12 - 17	2 - 3	4	5 - 6
Weapons	Shouldering, small arms, frozen fish	14.5mm or 23mm MG 12 barrel 107mm rocket launcher	Small arms 7.62 mm MG RPG - 7	12.7 mm MG 107 mm MRL	12.7 mm MG 107 mm MRL 106 mm Recoilless Rifle RPG - 7
Weapons	limited	200 - 1000 m	200+ m	800 - 1000 m	200 - 1000 m

USCG Desired NSC Configuration

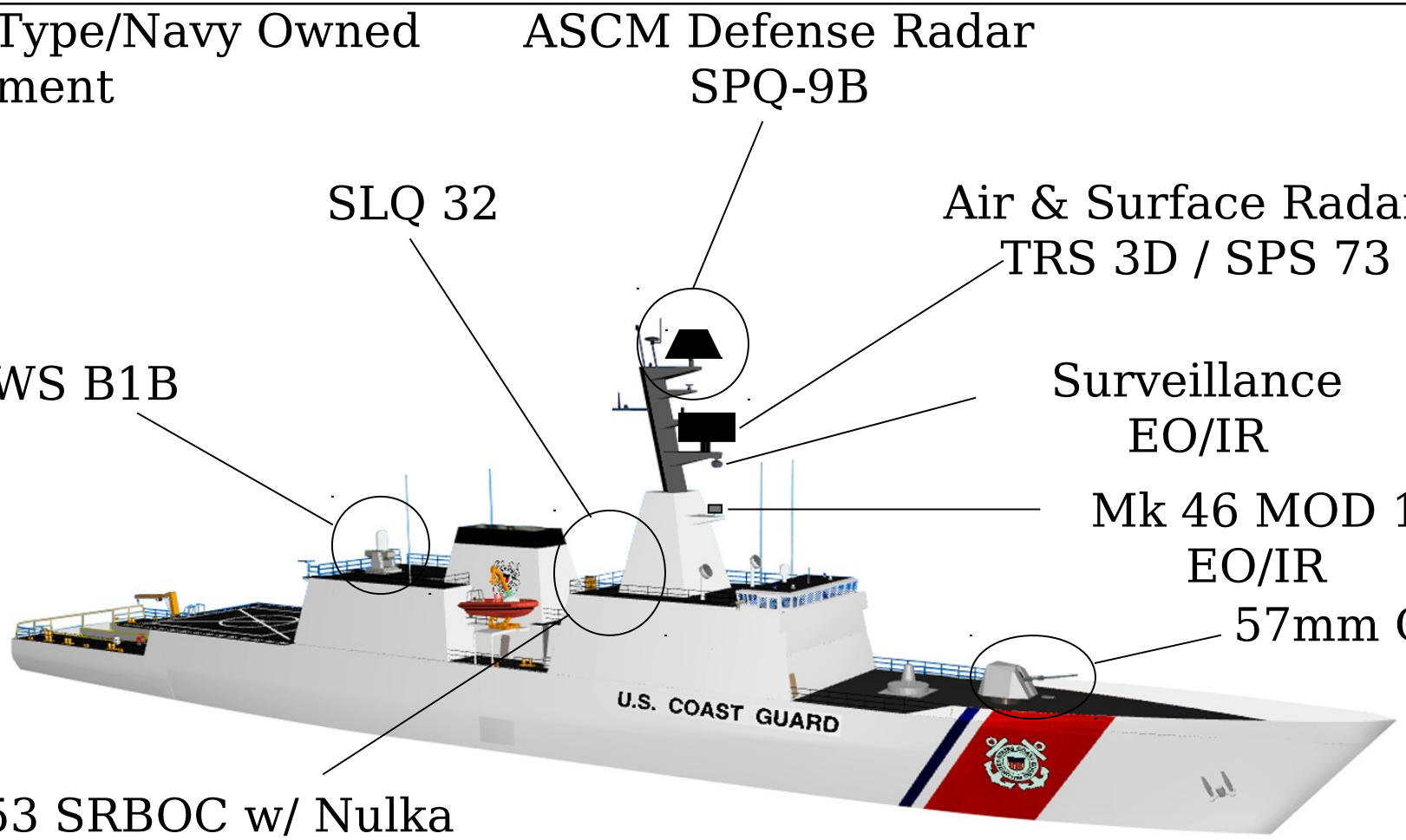
NT/NO w/ SLQ32 SEWIP and 2nd Surv. EO/IR

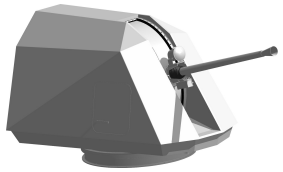


SAOP = Stand Alone Operator Position

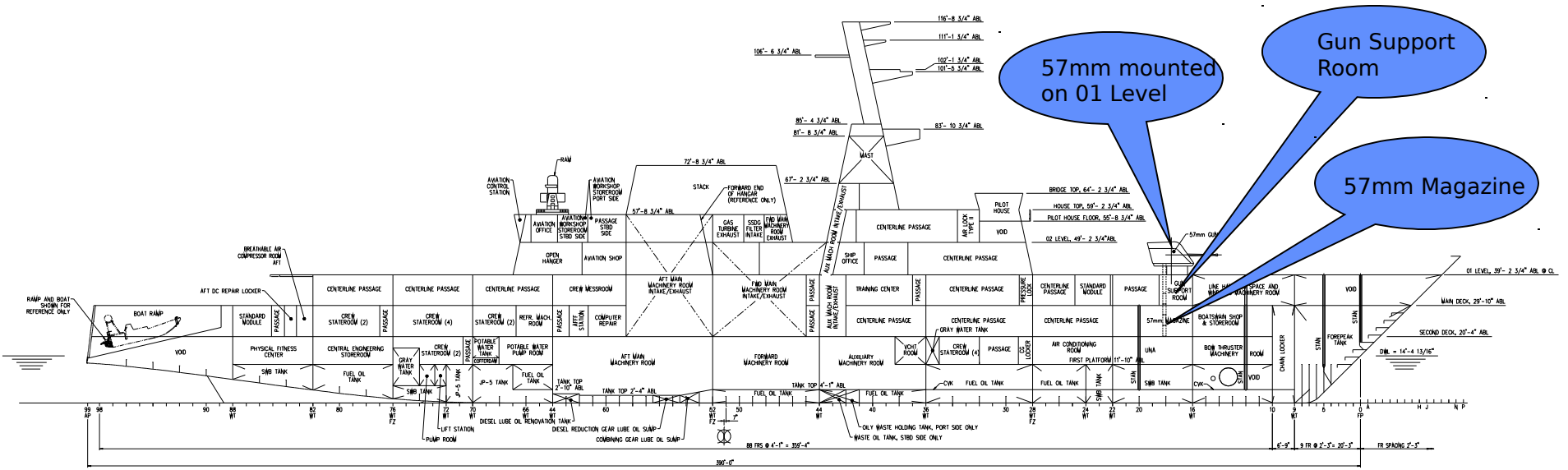
The National Security Cutter (NSC)

Navy Type/Navy Owned Equipment





BASELINE CONFIGURATION



NSC INBOARD PROFILE

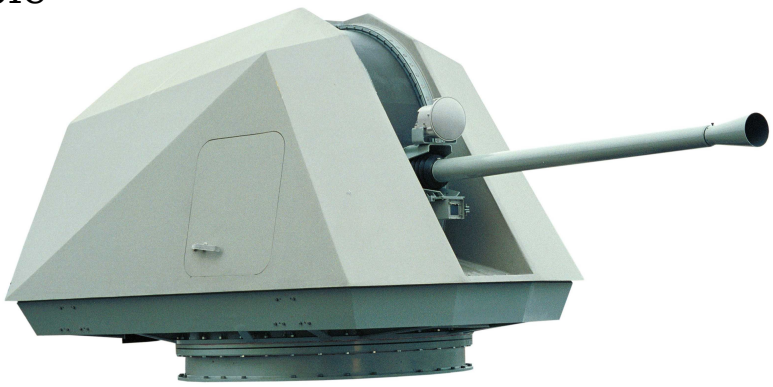
- 57mm L/70 Mk 3 Gun Selected for main battery for NSC
- Gun is mounted on 01 Level, approximately frame 18
- Gun Support Room is located on Main Deck, below Gun
- 57mm Magazine is located on Second Deck, below

Preliminary

57mm L/70 Mk 3 Gun Mount

- Mk 3 Gun in full production for Swedish, Finnish and Mexican Navy, under consideration for upgrade from Mk 2 to Mk 3 by Canadian Navy.
- General Characteristics
  - Manufacturer: UDLP/Bofors Defence
  - Weight: 6800 kgs
  - 120 rounds ready service ammo
  - 220 round/minute firing rate
  - Range: 17,000 meters using HCER ammunition
  - Barrel life: 5300 rounds
  - Power: 440VAC, 3 Phase, 60 Hz

57mm Mk 3 Gun w. standard copula
Low RCS weathershield available



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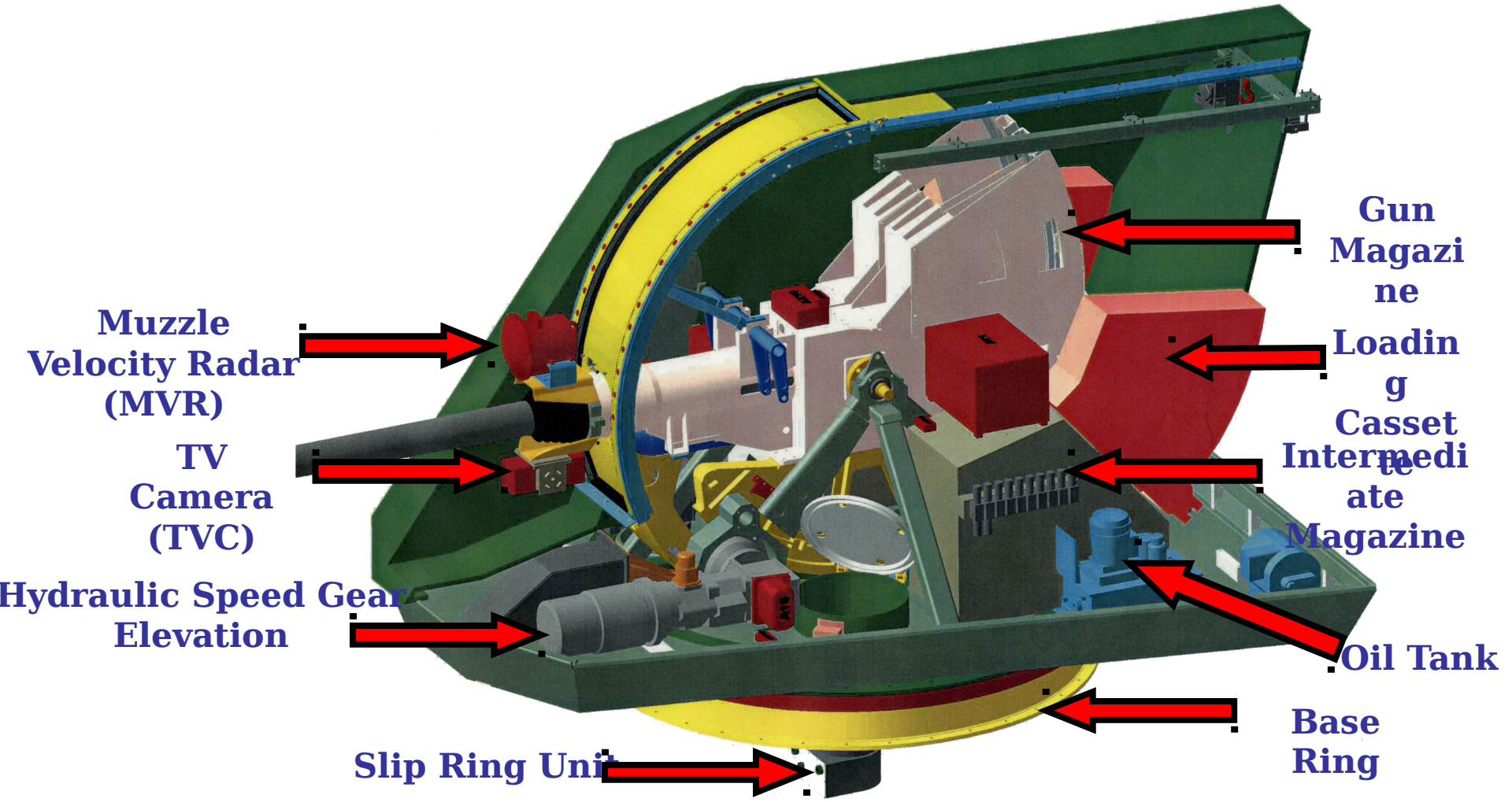
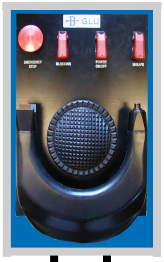
Deepwater GWS Gun Mount

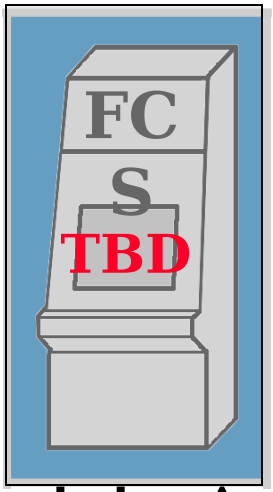


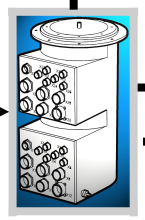
Control and Logic System

GLU



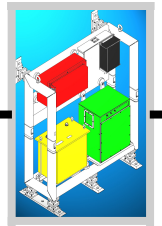
GCP





1553B Bus A

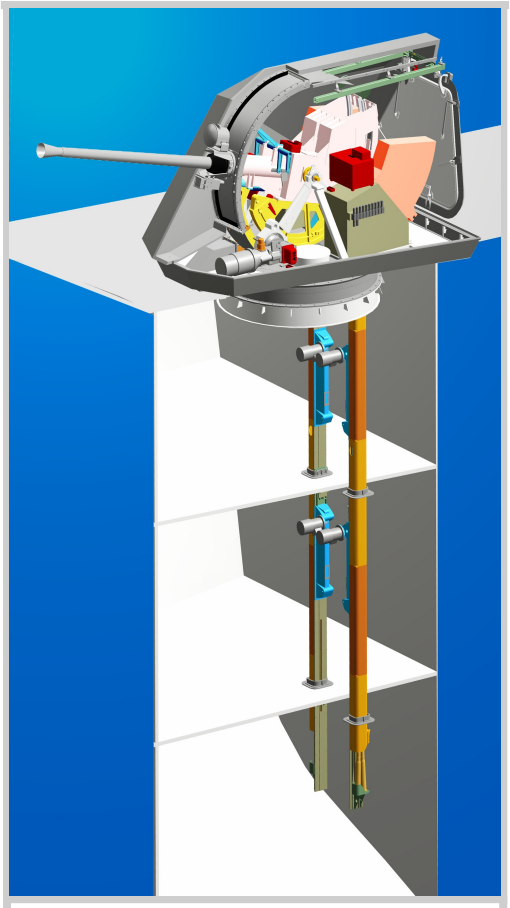
1553B Bus B



28VDC Power for all logic signals

Ammunition Loading System

- 2 identical independent systems
- Transports the ammunition from the ship magazine to the gun magazine
- 2 separate systems allow two types of ammunition simultaneously in the gun
- Automatic Reloading
- Controlled and operated from GCP/GCC or from the gun FCS



Logistics Demonstration and Engineering Analysis

- NSWC PHD Louisville and UDLP performed a Logistics Demonstration and Engineering Analysis to determine potential problems for fielding foreign intermediate caliber gun system.

Logistics Demonstration

- Logistics Demo Goals
  - For the Mk 3 57mm, Assess:
    - Safety related content of technical data provided by Bofors
    - Completeness of Technical Manuals provided
    - Correctness and completeness of maintenance tasks
    - Logistics support package provided by Bofors
    - Common and Peculiar Support Equipment, Special Tools & Test Equipment
    - Cross reference Petroleum, Oil and Lubricants to domestic equivalents
    - Provided Maintenance Requirement Cards (MRCs) for compatibility with U.S. Coast Guard and U.S. Navy requirements
    - Need for training materials and changes to Bofors data to meet current standards
    - Maintenance Tasks and the assigned levels (O, I or D)

LOGISTICS DEMO

- Review of Mk 3 57mm Technical Manuals
- Review of Mk 3 57mm Training Course Materials
- OEM Familiarization training review
- **O and I-Level** Preventive Maintenance Tasks
- **O and I-Level** Corrective Maintenance Tasks
- Major Component Replacement Tasks
- Final Evaluations and comments have been assembled into a Logistics Demonstration Report

57mm Mk 3 Gun being unpackaged and removed from shipping container in “A” Building, UDLP Louisville KY. The Gun and Lifting Fixtures are from Swedish Navy and normally used with Stealth Weathershield configuration for HMS VISBY.

LOGISTICS DEMO ANALYSIS

Logistics Elements

Design Interface – by Examination, Test and Demonstration

Manpower and Personnel - by Examination, Test and Demonstra

Training - by Examination, Test and Demonstration

Maintenance - by Examination, Test and Demonstration

Supply Support – by Analysis

Support and Test Equipment - by Examination, Test and Demonstration

Technical Data – CALS- by Analysis

Configuration Management – (NOT PART OF LOG DEMO)

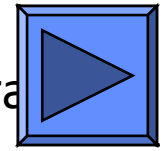
Computer Resources – by Analysis and Examination

Environmental, Safety and Occupational Health - by Examination, Test and Demonstration

Packaging, Handling, Storage & /Transportation – (NOT PART OF LOG DEMO)

Facilities – (NOT PART OF LOG DEMO)

ILS Management –by Analysis



Click here for description of results of logistics elements.

Notes from Logistics Demonstration

- Ability to perform tasks greatly enhanced by laptop computer based gun mount testing applications
  - A gun mount testing (GMT) laptop similar to the GCP shown at right and Gun Laying Unit (GLU) performs all these functions. This unit uses a PCMCIA 1553 card to interface to the GCC.
  - All items previously performed using Dummy Directors and chart recorders are programmed into GMT.
    - What used to take three days of I-level tasks can now be performed in a few hours.

Bofors supplied gun control panel (GCP) and gun laying unit (GLU). These items are on the MIL-STD-1553B bus and interface directly with the gun control computer (GCC) in the gun. Two GCPs can be connected on the bus along with FCC. Normally, a GCP and GLU are on the bridge or pilot house.

Engineering Assessment

- Engineering Assessment goals
  - Examine the 57mm Mk 3 Gun for areas of concern (safety, RM&A, other engineering shortcomings).
  - Make recommendations to the USCG (and Bofors Defence) for correction or consideration.

Engineering Assessment

- Maintenance Tasks
  - Factory Acceptance Test (FAT), Pre-FAT, HAT
    - Establishes gun performance baseline, verify gun condition
    - Performed water intrusion tests on gun port shield
  - Endurance Tests
    - Perform endurance tests based upon anticipated operational profile of Mk 3 gun in use by the U. S. Coast Guard and previous experience with MK 75.
    - Check for gun laying system (power-drive) temperatures extremes, system failures or weaknesses that will impact USCG missions.
  - Safety Assessment
    - During entire evolution and independently, evaluate gun for safety concerns (results feed into System Safety Working Group).
  - ORDALT Assessment
    - Based upon previous logistics demonstration, endurance tests and safety assessment, what engineering change proposals or ORDALTs would be required to field this gun mount with the USCG?

Endurance Test

- Simulated one year service use according to USCG mission profile, including 120 days of forward deployment and daily pre-fire checks
- Checked for system degradation via comparison of pre-test and post-test FATs, spectrochemical analysis of oil samples, and temperature data
- Tests performed by UDLP and Bofors Defence personnel, always in presence of ISEA personnel
- Non-firing tests only; follow-on gun qualification plan to include firing exercises when gun is shipped to Dahlgren
- Includes Water Intrusion Test

Water Intrusion Test

- Measure level of water intrusion on:
  - Weathershield and gun port seal
  - Base ring seal
  - Empty case ejection chute
  - BAE Muzzle velocity radar (MVR)
  - Access hatches
  - Ventilation aperture
  - Train warning speaker
  - Thales TVC submergence tested IAW MIL-STD-108E

Gun Port Shield Water Intrusion Test

Reliability and Hazard Analysis

- Safety Analysis
  - Review of Aiming and Firing Limits
  - Reliability Predictions and FMECA
  - Data generated by Bofors for the Swedish Navy, Mexican Navy, or historical data (Mk 1, Mk 2, Mk 3) leveraged
    - Bofors data translated from Swedish to English
  - Analysis could later be used in qualifying the Mk 3 to the WSESRB prior to U.S. Navy use

Safety Analysis

- Single Point Failures during specific events
  - Misaimed firing
  - Double ramming
  - Firing in a non-pointing zone
  - Accidental firing
- All safety-related variables in the Gun Control Computer are put in memory areas under a “check sum” control routine; no values can be changed without the routine immediately commanding an emergency stop of the GCC and gun
- Analysis shows that no single point failures can result in one of these critical events

Aiming & Firing Limits

- Aiming and Firing Limits are stored in the Gun Control Computer (GCC); can be reprogrammed using special equipment to conform to a different pattern required by the ship
- The GCC prevents firing/aiming if the gun receives control signals to send the barrel into a firing/aiming-limited area

Reliability Predictions and FMECA

- MTBF data received from Bofors; much of the reliability info comes from Mk 2 maintenance records; MIL Handbook 217 used for any parts w/no historical data
- FMECA analysis investigates catastrophic occurrences (intolerable risk) expected during the service life of the gun system.

Hazard Risk Index Matrix

Frequency of Occurrence	Hazard Categories			
	I Catastrophic	II Critical	III Marginal	IV Negligible
A - Frequent				
B - Probable				
C - Occasional				
D - Remote				
E - Improbable				

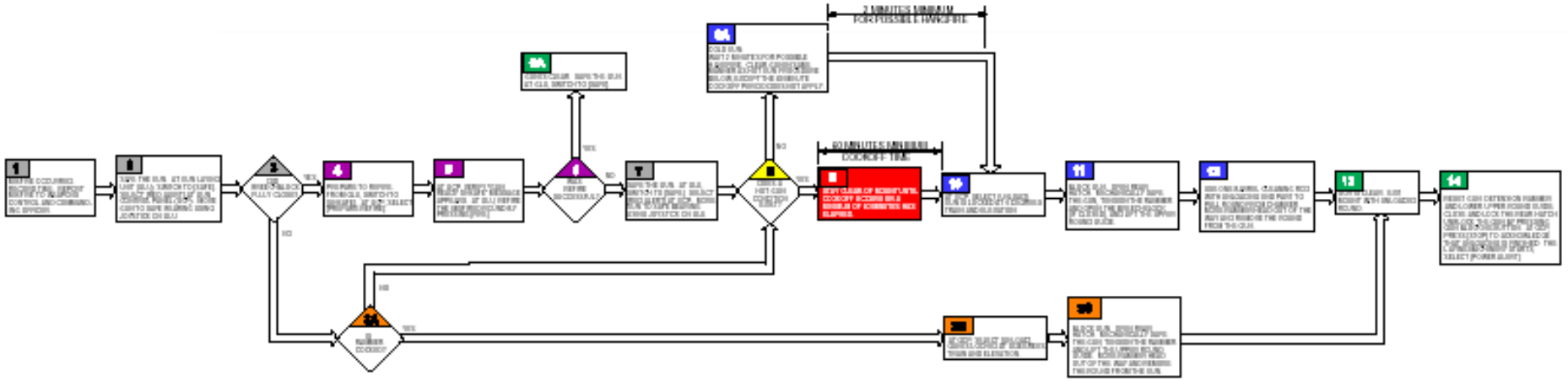
Legend:	
HIGH	Approval of the Assistant Secretary of the Navy (Research, Defense & Acquisition) required.
SERIOUS	Program Executive Officer approval required.
MEDIUM	Program Manager approval required.
LOW	Program Manager approval required.

ORDALT Assessment

- ORDALT Analysis conducted with input from ISEA, USCG, UDLP, and Bofors personnel
- Recommendations were accumulated during a focused analysis period in March and during the Operator's Training Course, Logistics Demonstration, Endurance Test and Safety Assessment conducted at NSWC PHD Louisville and United Defense Louisville.
- Analysis identified (20) recommended modifications to the 57mm Mk 3 to field this gun mount with the USCG
- Also considered required changes to meet U.S. Navy standards in preparation for possible future use in the U.S. Navy

Misfire Procedures Review

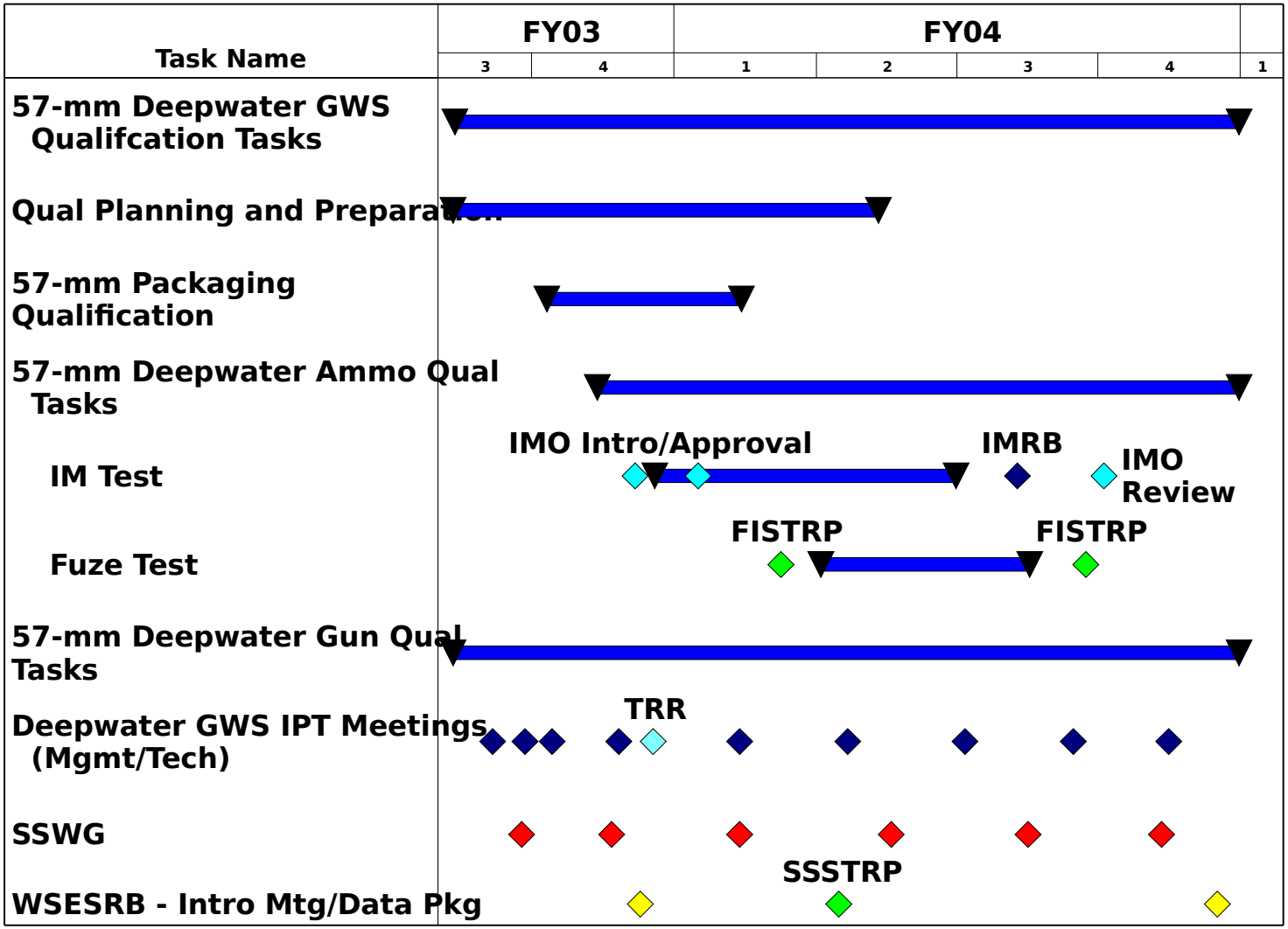
- NSWC PHD/L ISEA developed misfire flowchart based upon Swedish Navy and Bofors Defence procedures
  - All events will be reviewed and amended during gun and ammunition qualifications at NSWC Dahlgren.
  - Will revisit in upcoming SSWGs



GWS Qualification Program Lead Activities

- NSWC - System Safety Program Management
  - Principal for Safety is Fred Hartley (NSWCDD)
  - Lead Safety Engineer is Dan Holmes (NSWCPHD/L)
- NSWCDD - Technical Direction Agent (TDA) and Gun/Ammo System Integration Agent (SIA) for the program
- NSWCPHD/L - Acquisition Engineering Agent (AEA) and In-Service Engineering Agent (ISEA)
- NAVSEA PM4 - Ammo management and procurement

GWS Qualification Schedule

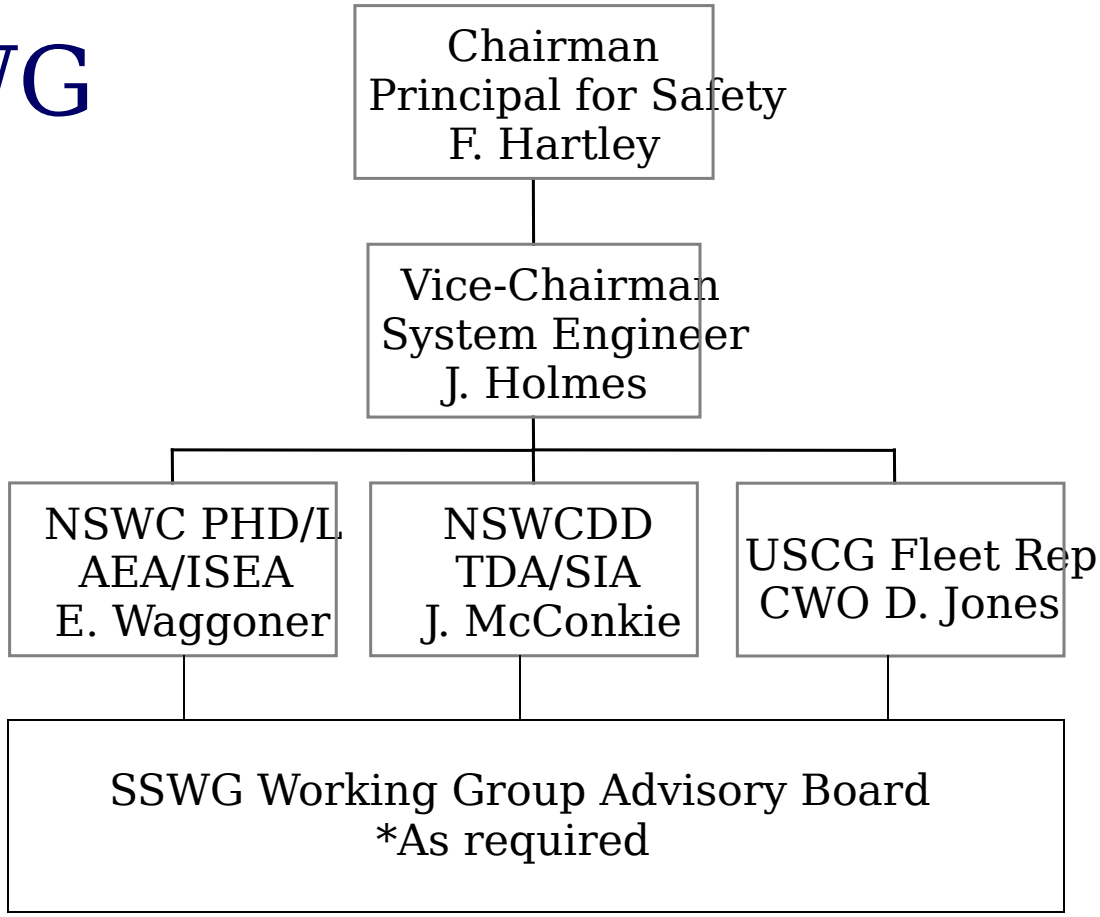


System Safety Program

- System Safety Program Plan (SSPP)
- System Safety Working Group (SSWG) Charter
- Threat Hazard Assessment (THA)
- Fault Tree Analysis (FTA)
- Preliminary Hazard Analysis (PHA)
- Operating & Support Hazard Analysis (O&SHA)
- System Hazard Analysis (SHA)
- Software Safety and Hazard Analysis

System Safety Program

- SSWG



System Safety Program

- Environmental Concerns
  - Programmatic Environmental Safety and Health Evaluations
  - Hazardous materials, ammunition, pollution prevention
- Surveillance / Demil Disposal Plans
- EOD & NMD Documentation
- Ammo Insensitive Munitions Tests
- HERO, EMV, EMC & ESD Testing
- Performance Oriented Packaging (POP) Certification Testing
- GWS Hot Gun procedures based upon Cook-off Test Plan
- Explosive Hazard Classification / Qual Tests
- Configuration Management Plan for the Gun & Ammo

System Engineering Conclusions

- System Engineering of 57mm MK 3 Gun Involves Many Aspects
  - Requirements
    - 57mm L/70 Mk 3 Gun meets USCG requirements for NSC mission
  - Logistics elements in place but need refinement
    - Technical manuals, other data elements need refinement to USN/USCG standards
    - System design makes distant support easy
    - Life-cycle support thought of from the start
  - Safety
    - Gun and Ammunition WSESRB Qualification will thoroughly examine safety of the system
- System Engineering approach makes total system safety and effectiveness a success.

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USCG

Questions?